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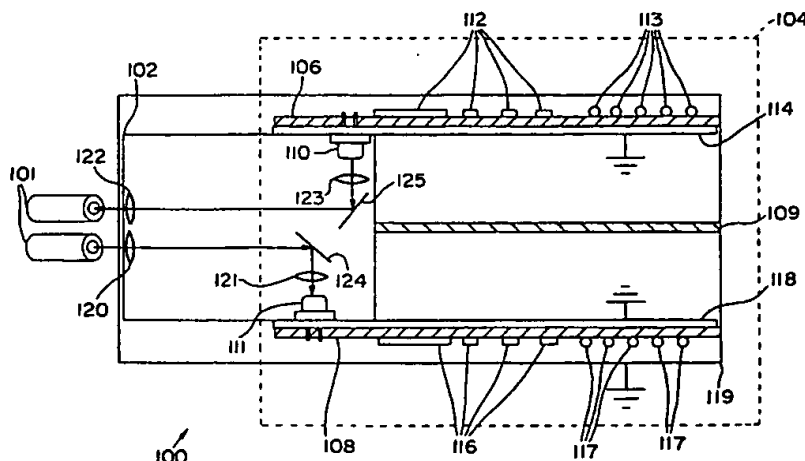
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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(54) Title: METHOD AND APPARATUS FOR VERTICAL BOARD CONSTRUCTION OF FIBER OPTIC TRANSMITTERS, RECEIVERS AND TRANSCEIVERS



(57) Abstract: Fiber optic transmitter electrical elements (112, 116) are implemented on separate vertical boards (106, 108) in a fiber optic module (100). A single optical block (102) implements lenses (120-123) and reflecting surfaces (124, 125) to minimize manufacturing costs. In one embodiment the receiver (111) and transmitter (110) are mounted to receive and transmit vertical boards (108, 106) respectively to nearly face each other but being offset to avoid optical cross talk. In a second embodiment, the receiver and transmitter are mounted parallel with the printed circuit boards to save additional space. The vertical boards (106, 108) have ground planes (114, 118) to minimize electrical cross talk. A shielded housing (119) provides further shielding for EMI. Manufacturing steps of the fiber optic transceiver (100) are disclosed which provide reduced manufacturing costs.

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OE and EE are connected electrically at the emitter and photodetector.

Because of the high transmission frequencies utilized in fiber optic communication, crosstalk between receive and transmit signals is of concern. Additionally, electromagnetic interference (EMI) is of concern due to the high frequency of operation of the fiber optic modules. In order to reduce EMI, shielding of the electrical components is required which is usually accomplished by attaching a metal shield to the substrate of the fiber optic module and connecting it to ground. In order to avoid electronic crosstalk and EMI, the fiber optic transceiver usually employs separate components and separate shielding of fiber optic receiver and fiber optic transmitter components. In order to avoid optical crosstalk where light or photons can interfere between communication channels, the fiber optic transceiver usually employs separate optical elements for coupling light or photons into and out of the optical fiber for fiber optic receiver and fiber optic transmitter. Using separate optical elements requires additional components and increases the costs of fiber optic transceivers. It is desirable to reduce the component count of fiber optic transceivers such that they are less expensive to manufacture.

The form factor or size of the fiber optic module is of concern. Previously, the fiber optic transceiver, receiver, and transmitter utilized horizontal boards or substrates which mounted parallel with a system printed circuit board utilized significant footprint or board space. The horizontal boards provided nearly zero optical crosstalk and minimal electronic crosstalk when properly shielded. However, the horizontal boards, parallel to the system printed circuit board, required

photons through ninety degrees, the light transmitter (a packaged type of emitter) and a light receiver (a packaged type of photodetector) are each mounted substantially perpendicular to the transmit and receive boards respectively such that their active areas are nearly facing each other but offset. A single optical block implements lenses and reflecting surfaces to minimize manufacturing costs. The light receiver and light transmitter are mounted offset from each other in the optical block in order to avoid optical cross talk.

In a second embodiment, the light transmitter (emitter) and the light receiver (photodetector) are each mounted substantially parallel with the transmit and receive boards respectively and the connection to the optical fibers. The separate and substantially parallel receive and transmit boards are provided with ground planes on back sides in order to minimize electrical cross talk. A module outer shielded housing, manufactured out of metal or metal plated plastic, provides further shielding for EMI. The substantially parallel boards may be extended to support multiple channels or multiple parallel fibers such as in a ribbon optical fiber cable. Manufacturing steps of the boards for the fiber optic module are disclosed to provide reduced manufacturing costs.

#### BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. 1 is a simplified top cutaway view of a first embodiment of the present invention.

FIG. 2 is an exploded view of the first embodiment of the present invention.

FIG. 3A is a cross-sectional view from the top of the optic block for the first embodiment of the present

FIG. 6C is a back side view of the optic block for the second embodiment of the present invention.

FIG. 6D is a top side view of the optic block for the second embodiment of the present invention.

FIG. 7A is a top view of a manufacturing step of the present invention.

FIG. 7B is a side view of a manufacturing step of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one skilled in the art that the present invention may be practiced without these specific details. In other instances well known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the present invention.

The present invention includes a method, apparatus and system for method, apparatus and system for vertical board construction of fiber optic transmitters, receivers and transceivers. Briefly, fiber optic transmitter and receiver electrical elements are implemented on two separate substantially parallel boards in a fiber optic module. The parallel boards are mount substantially perpendicular to the base of the fiber optic module and the system printed circuit board to which it attaches, to reduce the footprint of the fiber optic module. In one embodiment, bending light or photons through ninety degrees, the light transmitter (a packaged type of emitter) and a light receiver (a

communicating with optical fibers using light of various wavelengths or photons. An optoelectronic device is a device which can convert or transduce light or photons into an electrical signal or an electrical signal into light or photons. The transmitter 110 is a packaged emitter, that converts an electrical signal into emitting light or photons, such as a semiconductor laser or LED, preferably packaged in a TO can. The receiver 111 is a packaged photodetector, that detects or receives light or photons and converts it into an electrical signal, such as a photo diode, preferably package in a TO can. However other packages, housings or optoelectronic devices for receiving and transmitting light or photon may be used for the receiver 111 or transmitter 110.

Each of the optoelectronic devices, receiver 111 and transmitter 110, have terminals to couple to thruholes of the PCBs 106 and 108. The transmit PCB 106 includes electrical components 112 (transmitter integrated circuit (laser driver), resistors, capacitors and other passive or active electrical components), pins 113, and a ground plane 114. The electrical components 112 control the transmitter 110 and buffer the data signal received from a system for transmission over an optical fiber. The receive PCB 108 includes electrical components 116 (receiver integrated circuit (transimpedance amplifier and post amplifier), resistors, capacitors and other passive or active electrical components), pins 117, and a ground plane 118. The electrical components 116 control the receiver 111 and buffer the data signal received from an optical fiber. The ground planes 114 and 118 and the shielded housing 119 are coupled to ground. The electrical components 116 and pins 117 are sandwiched between the ground plane 118 and the shielding 119 to shunt electro-

102 described below are formed through injection molding of the desired material.

Referring to FIG. 2, an exploded diagram of the fiber optic module 100 is illustrated and its assembly is described. Transmitter 110 is inserted into an opening 214 in the optical block 102. Receiver 111 is inserted into an opening 213 in optical block 102. An epoxy is injected into top and bottom tacking holes 215 in order to hold the transmitter 110 and receiver 111 in openings 214 and 213 respectively. An MT alignment plate 201 has optical block alignment holes 216, an optical opening 217 and fiber optic connector alignment pins 218 for alignment purposes. The optical block holes 216 couple to optical block alignment pins in the optical block 102, not illustrated in FIG. 2. The fiber optic connector alignment pins 218 are for aligning optical fibers that couple to the fiber optic module 100.

For coupling to a fiber optic connector, the fiber optic module 100 has a nose 202 and a nose shield 203. The nose 202 includes a optical fiber opening 222 and a latch opening 223. The latch opening 223 receives the optical fiber connector and holds the optical fiber substantially fixed in place and aligned with the optical opening 217 of the alignment plate 201. The nose shield 203 includes an opening 224 for insertion over the nose 202 and shield tabs 225 for coupling to the ground plane of the package. The nose shielding 203 further reduces EMI.

After assembling the nose pieces to the optical block 102, the transmitter 110 and receiver 111 may be aligned to provide optimal light or photon output and reception.

Alignment of the transmitter 110 and receiver 111 in optical block 102 is performed by active alignment where the receiver 111 and transmitter 110 are powered up to

The shielded housing 119 includes clips 236 at each corner for mating to a base 205. The base 205 includes PCB slots 240, clip openings 238 into which the clips 236 may be inserted, and base pin holes 242 into which the PCB pins 113 and 117 may be inserted. The base 205 includes a guide post 244 for mounting the fiber optic module into a system printed circuit board. The bottom of the base mounts parallel to the printed circuit board of the system such that when horizontal, the receive PCB 108 and the transmit PCB 106 are vertical and substantially perpendicular in reference to the printed circuit board of the system and the base 205. Next in assembly, the base 205 has its base pin holes 242 slid over the PCB pins 113 and 117, the printed circuit boards 106 and 108 are guided to mate with the PCB slots 240, and the clips 236 of the shielded housing 119 are guided into the clip openings 238. The receive PCB pins 113 and the transmit PCB pins 117 are vertical and substantially perpendicular in reference to the printed circuit board of the system and the base 205. After coupling the base 205 to the shielded housing 119, the clips 236 are bent, twisted, or otherwise changed in order to hold the base 205 in place. As an alternative to clips 236 and clip openings 238, the shielded housing 119 may use plastic clips, or a ridge, integrated into each side that couples to base 205 appropriately. The shielded housing 119, which is coupled to ground, encases the PCBs 106 and 108 to reduce the electromagnetic fields generated by the electrical components coupled thereto by shunting the electric fields to ground to reduce electromagnetic interference (EMI).

Referring now to FIG. 3A, a cross-sectional view of the optical block 102 for the first embodiment is illustrated. The transmitter 110, the receiver 111, and the MT alignment plate 201 are coupled to the optical



the light or photons received from a fiber optical cable onto the detector 304. Light or photons incident from a fiber optic cable, defining a second optical axis, are substantially perpendicular to the light or photons incident upon the detector 304.

FIG. 3B illustrates a frontal perspective view from the left side of the optical block 102. The front side of the optical block 102 includes optical block alignment pins 316 and an optical output opening 317. The optical block alignment pins 316 couple to the alignment holes 216 of the alignment plate 201 such that the optical output opening 317 is aligned with the optical port 217 in the alignment plate 201. FIG. 3C illustrates the front side of the optical block 102. The optical output opening 317 is indicated.

FIG. 3D is a back side perspective view from the right of the optical block 102. The back side of the optical block 102 includes a cavity 322 that is used to form the shape of the reflective surfaces 124-125 during manufacturing of the optical block 102. FIG. 3E is a back view of the optic block illustrating the opening into the cavity 322.

FIG. 3F illustrates the right side of the optical block 102 which has the opening 214 to mate with the type of housing of the transmitter 110. The lens 123 can be viewed near the center of the opening 214. FIG. 3G illustrates the left side of the optical block 102. which has the opening 213 to mate with the type of housing of the receiver 111. The lens 121 can be viewed near the center of the opening 213. Comparing FIGs. 3F and 3G, the offset between openings 213 and 214 to avoid optical crosstalk is visible. In the preferred embodiment, receiver 111 is closer to the optical opening 317 in order to minimize the loss of incoming

514 respectively in the optical block 402. An epoxy is injected in top and bottom tacking holes 515 of the optical block 402 and the receiver 111 and transmitter 110 are tested and aligned to substantially couple light or photons into and out of fiber optic cables. After the epoxy is set and the receiver and transmitter are substantially fixed in the optical block 102, the transmit PCB 106 and the receive PCB 108 are coupled respectively to the transmitter 110 and the receiver 111. The terminals 511 and 510 of the receiver 111 and the transmitter 110 respectively are soldered directly onto the PCB. The high frequency pins associated with the receiver 111 and transmitter 110 are preferably soldered on the component side of the printed circuit boards in order to provide proper shielding. The alignment plate 201, the nose 202 and the nose shielding 203 are unnecessary in this embodiment of the present invention. Fiber ferrules are utilized instead for alignment between the optical block 402 and the optical fibers 101.

Referring now to FIG. 6A, a cross-sectional view of the optical block 402 for the second embodiment is illustrated. The transmitter 110 and the receiver 111 are coupled to the optical block 402. The transmitter 110 includes an emitter 302 for generation of light or photons. The receiver 111 includes a detector 304 to receive light or photons. Light or photons emitted by the emitter 302 are coupled into lens 423, collected and focused into the optical fiber through the optical port 417A. Light or photons, incident from a fiber optic cable coupled to the fiber optic module 400, is received through the optical port 417B. Photons from the fiber optic cable are incident upon the lens 421. Lens 421 collects and focuses the incident light or photons from the fiber optic cable onto the detector 304 of the

optic modules as including a receiver and transmitter. However, one of ordinary skill can see that a fiber optic module may be a receiver only or a transmitter only such that only one board may be substantially perpendicular to the base. Additionally, the previous detailed description described one PCB board for receive and transmit functions. However, the present invention may be extended to a plurality of PCB boards substantially in parallel for providing transmit or receive functionality or both into parallel fiber optic cables.

As those of ordinary skill will recognize, the present invention has many advantages over the prior art. One advantage of the present invention is that the shielded housing provides one EMI shield for a fiber optic transceiver instead of two separated EMI shields that are ordinarily required. Another advantage of the present invention is that vertical PCBs provide a narrower width of fiber optic module to provide a coupling to narrower optical fiber connectors. Another advantage of the present invention is that ground planes of the vertical PCBs reduce cross talk. Another advantage of the present invention is that the physical separation of the receive and transmit optical elements and electrical elements provides superior isolation and minimizes optical and electrical cross-talk.

The preferred embodiments of the present invention for METHOD AND APPARATUS FOR VERTICAL BOARD CONSTRUCTION OF FIBER OPTIC TRANSMITTERS, RECEIVERS AND TRANSCEIVERS are thus described. While the present invention has been described in particular embodiments, the present invention should not be construed as limited by such embodiments, but rather construed according to the claims that follow below.

fiber, the fiber optic module further comprising:

an optical block coupled to the optoelectronic device, the optical block having a first lens to couple photons between the optoelectronic device and an optical fiber.

4. The fiber optic module of claim 3 for coupling photons between an optoelectronic device and an optical fiber, wherein,

the optical block has a pair of optical block posts for alignment, and

the fiber optic module further comprises:

an optical fiber alignment plate having a pair of optical block alignment holes coupled to the optical block posts for coupling in alignment the alignment plate to the optical block, the alignment plate having an optical opening to allow passage of photons and a fiber optic post on a back side for coupling in alignment an optical fiber with the optical opening.

5. The fiber optic module of claim 4 for coupling photons between an optoelectronic device and an optical fiber, the fiber optic module further comprising:

a nose coupled to the base, the nose for receiving an optical fiber connector and holding an optical fiber substantially fixed and aligned with the optical opening of the alignment plate.

6. The fiber optic module of claim 4 for coupling photons between an optoelectronic device and an optical fiber, the fiber optic module further comprising:

a nose shield surrounding the nose for reducing electromagnetic interference.

fiber, wherein,

the optoelectronic device is coupled substantially perpendicular to the printed circuit board, and

the optical block further comprises:

a reflective surface for reflecting photons between the optoelectronic device and the first lens; and

a second lens for coupling photons between the optoelectronic device and the reflective surface.

13. The fiber optic module of claim 12 for coupling photons between an optoelectronic device and an optical fiber, wherein,

photons are to be received from an optical fiber,

the first lens of the optical block is a collimating lens for receiving photons from the optical fiber and directing them towards the reflective surface,

the reflective surface reflects photons received by the first lens towards the second lens and the optoelectronic device, and

the second lens of the optical block is a focusing lens for focusing photons from the reflective surface into the optoelectronic device.

14. The fiber optic module of claim 13 for coupling photons between an optoelectronic device and an optical fiber, wherein,

the optoelectronic device is a photodetector.

15. The fiber optic module of claim 12 for coupling photons between an optoelectronic device and an optical fiber, wherein,

photons are to be launched into an optical fiber,

the first lens of the optical block is a collimating lens for receiving photons from the

photons between an optoelectronic device and an optical fiber, wherein,

the reflective surface is an optical grating surface to scramble photo-modes and to reflect the photons.

21. A fiber optic transceiver for coupling photons between optoelectronic devices and optical fibers, the fiber optic transceiver comprising:

a base having a first slot near one side, a second slot near an opposite side of the first slot, a first plurality of pin holes near the one side and a second plurality of pin holes near the opposite side, the base for mounting the fiber optic transceiver in a system for coupling photons between an optoelectronic device and an optical fiber;

a first printed circuit board (PCB) inserted into the first slot substantially perpendicular to the base, the first PCB having a plurality of pins inserted into the first plurality of pin holes and a first optoelectronic device for communicating with a first optical fiber using photons, the first optoelectronic device having terminals coupled to the first PCB;

a second PCB inserted into the second slot substantially perpendicular to the base, the second PCB having a second plurality of pins inserted into the second plurality of pin holes and a second optoelectronic device for communicating with a second optical fiber using photons, the second optoelectronic device having terminals coupled to the second PCB; and

a shielded housing coupled to the base, the shielded housing encasing the first PCB and the second PCB to reduce electromagnetic interference (EMI).

22. The fiber optic transceiver of claim 21 for

optical fibers, the fiber optic transceiver further comprising:

an optical block coupled to the first optoelectronic device and the second optoelectronic device, the optical block having a first lens to couple photons between the first optoelectronic device and a first optical fiber and a second lens to couple photons between the second optoelectronic device and a second optical fiber.

25. The fiber optic transceiver of claim 24 for coupling photons between optoelectronic devices and optical fibers, wherein,

the optical block has a pair of optical block posts for alignment, and

the fiber optic transceiver further comprises:

an optical fiber alignment plate having a pair of optical block alignment holes coupled to the optical block posts for coupling in alignment the alignment plate to the optical block, the alignment plate having an optical opening to allow passage of photons and a pair of fiber optic posts on a back side for coupling in alignment a pair of optical fibers with the optical opening.

26. The fiber optic transceiver of claim 25 for coupling photons between optoelectronic devices and optical fibers, the fiber optic transceiver further comprising:

a nose coupled to the base, the nose for receiving an optical fiber connector and holding a pair of optical fibers substantially fixed and aligned with the optical opening of the alignment plate.

27. The fiber optic transceiver of claim 26 for

32. The fiber optic transceiver of claim 29 for coupling photons between an optoelectronic devices and optical fibers, wherein,

the first optoelectronic device is a photodetector,  
and

the second optoelectronic device is an emitter.

33. The fiber optic transceiver of claim 32 for coupling photons between an optoelectronic devices and optical fibers, wherein,

the emitter is a vertical cavity surface emitting laser (VCSEL).

34. The fiber optic transceiver of claim 24 for coupling photons between optoelectronic devices and optical fibers, wherein,

the first optoelectronic device is coupled substantially perpendicular to the first printed circuit board and the second optoelectronic device is coupled substantially perpendicular to the second printed circuit board such that the first printed circuit board and the second printed circuit board are substantially parallel to each other and the first and second optoelectronic devices nearly face each other, and

the optical block further comprises:

a first reflective surface for reflecting photons between the first optoelectronic device and the first lens;

a second reflective surface for reflecting photons between the second optoelectronic device and the second lens;

a third lens for coupling photons between the first optoelectronic device and the first reflective surface; and

a fourth lens, for coupling photons between the



second reflective surface,

the second reflective surface is for reflecting photons received from the fourth lens and directing them towards the second lens and the optical fiber, and

the second lens of the optical block is a focusing lens for focusing photons from the second reflective surface into a second optical fiber.

38. The fiber optic transceiver of claim 37 for coupling photons between optoelectronic devices and optical fibers, wherein,

the second optoelectronic device is an emitter.

39. The fiber optic transceiver of claim 38 for coupling photons between optoelectronic devices and optical fibers, wherein,

the emitter is a vertical cavity surface emitting laser (VCSEL).

40. The fiber optic module of claim 35 for coupling photons between an optoelectronic device and an optical fiber, wherein,

the fourth lens of the optical block is a collimating lens for receiving photons from the second optoelectronic device and directing them towards the second reflective surface,

the second reflective surface is for reflecting photons received from the fourth lens and directing them towards the second lens and the optical fiber, and

the second lens of the optical block is a focusing lens for focusing photons from the second reflective surface into a second optical fiber.

41. The fiber optic transceiver of claim 40 for

comprising:

an internal shield inserted between the first PCB and the second PCB, the internal shield further reducing electrical crosstalk.

47. A method of assembling a fiber optic transceiver, the method comprising:

- a) providing an optical block having lenses and reflectors for directing photons
- b) coupling a transmitting optoelectronic device and a receiving optoelectronic device to the optical block
- c) providing a single printed circuit board having transmit electronics and receive electronic components separated by a score; and
- d) flexing the printed circuit board near the score to separate the single printed circuit board into a transmit printed circuit board and a receive printed circuit board for coupling respectively to the transmitting optoelectronic device and the receiving optoelectronic device.

48. The method of claim 47 of assembling a fiber optic transceiver, the method further comprising:

- e) installing the present assembly into a shielded housing to reduce electromagnetic interference; and
- f) coupling a base to the shielded housing, the base having a pair of parallel slots to couple substantially perpendicular to the transmit printed circuit board and the receive printed circuit board such that the transmit printed circuit board and the receive printed circuit board are substantially parallel to each other.

49. The method of claim 47 of assembling a fiber

a receive opening on one side of the optical block for receiving the receiver,

a transmit opening on an opposite side of the optical block for receiving the transmitter, the transmit opening staggered from the receiving opening to avoid optical crosstalk between the transmitter and the receiver,

a first lens, a first reflector and a third lens in an optical path between the receive opening and a first area for coupling photons into a first optical fiber, and

a second lens, a second reflector and a fourth lens in an optical path between the transmit opening and a second area for coupling photons into a second optical fiber.

53. The fiber optic transceiver of claim 52 for transmitting and receiving photons over optical fibers, wherein the optical block of the fiber optic transceiver further has:

a top pair of tacking holes coupling to the receive opening and the transmit opening, the top pair of tacking holes for receiving an epoxy to hold the receiver and the transmitter respectively in place.

54. The fiber optic transceiver of claim 53 for transmitting and receiving photons over optical fibers, wherein the optical block of the fiber optic transceiver further has:

a bottom pair of tacking holes coupling to the receive opening and the transmit opening, the bottom pair of tacking holes for receiving an epoxy to hold the receiver and the transmitter respectively in place.

55. The fiber optic transceiver of claim 52 for

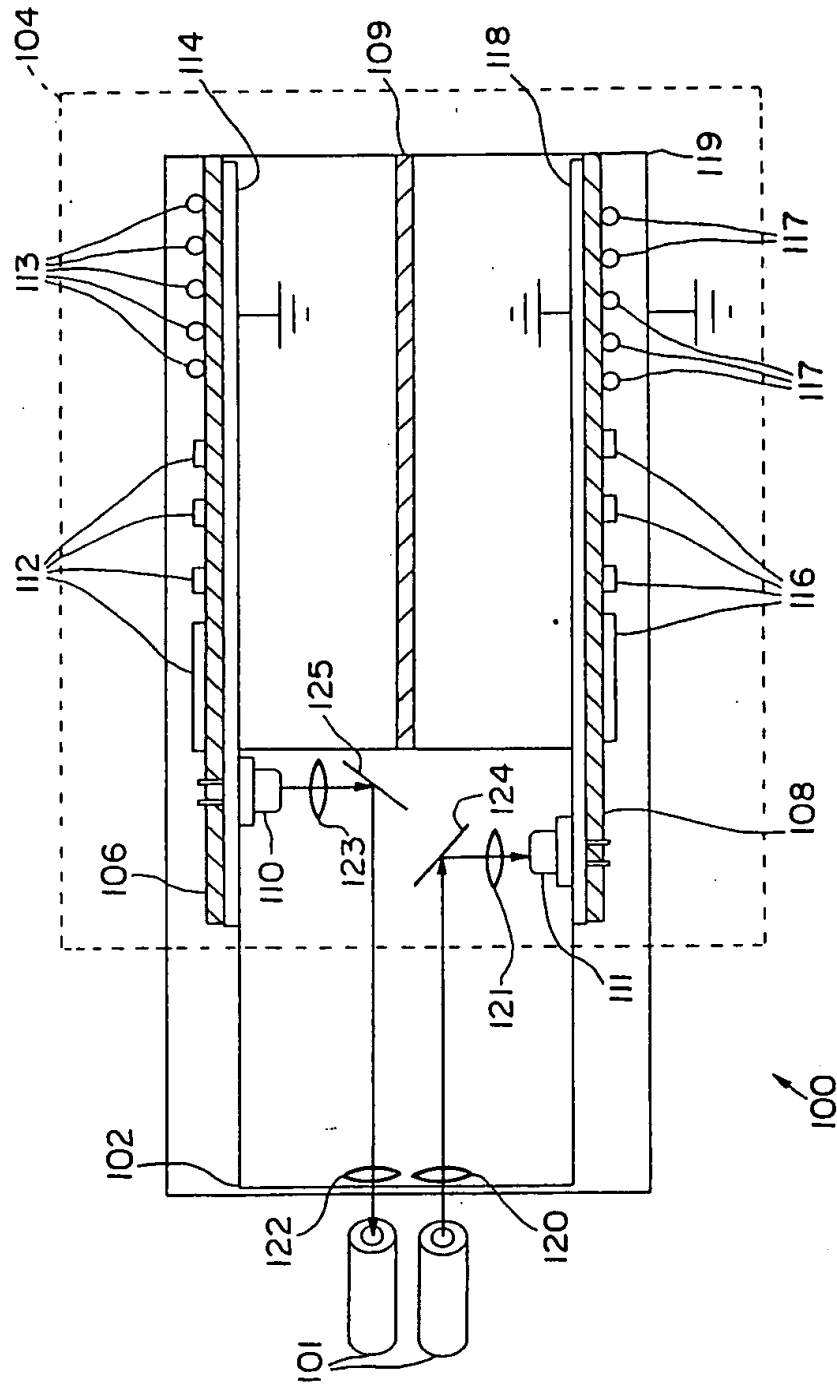


FIG. 1

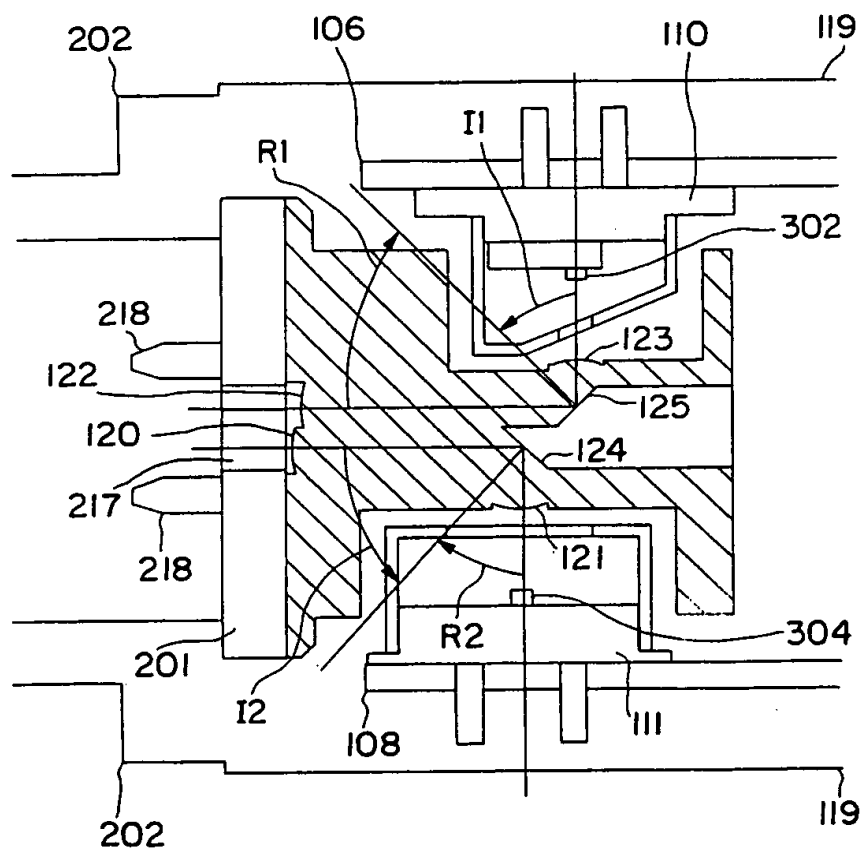


FIG. 3A

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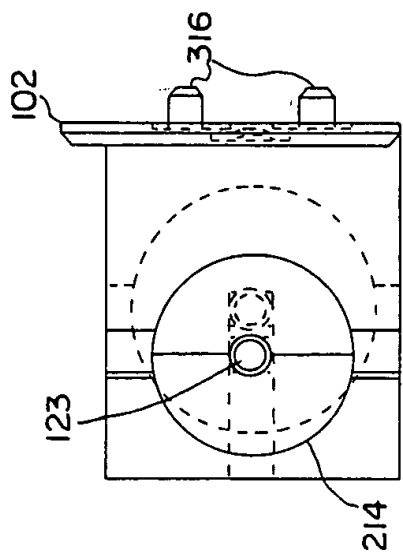


FIG. 3F

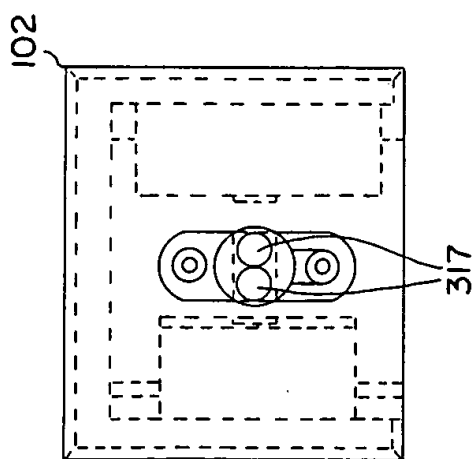


FIG. 3C

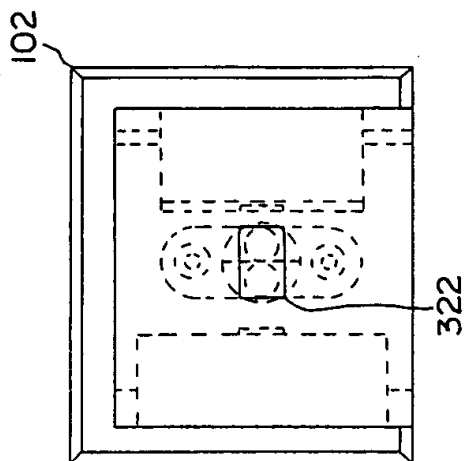


FIG. 3E

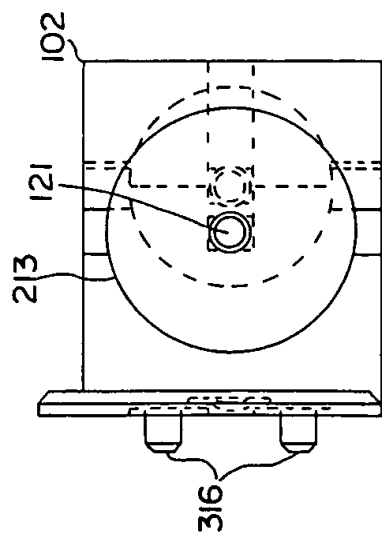


FIG. 3G

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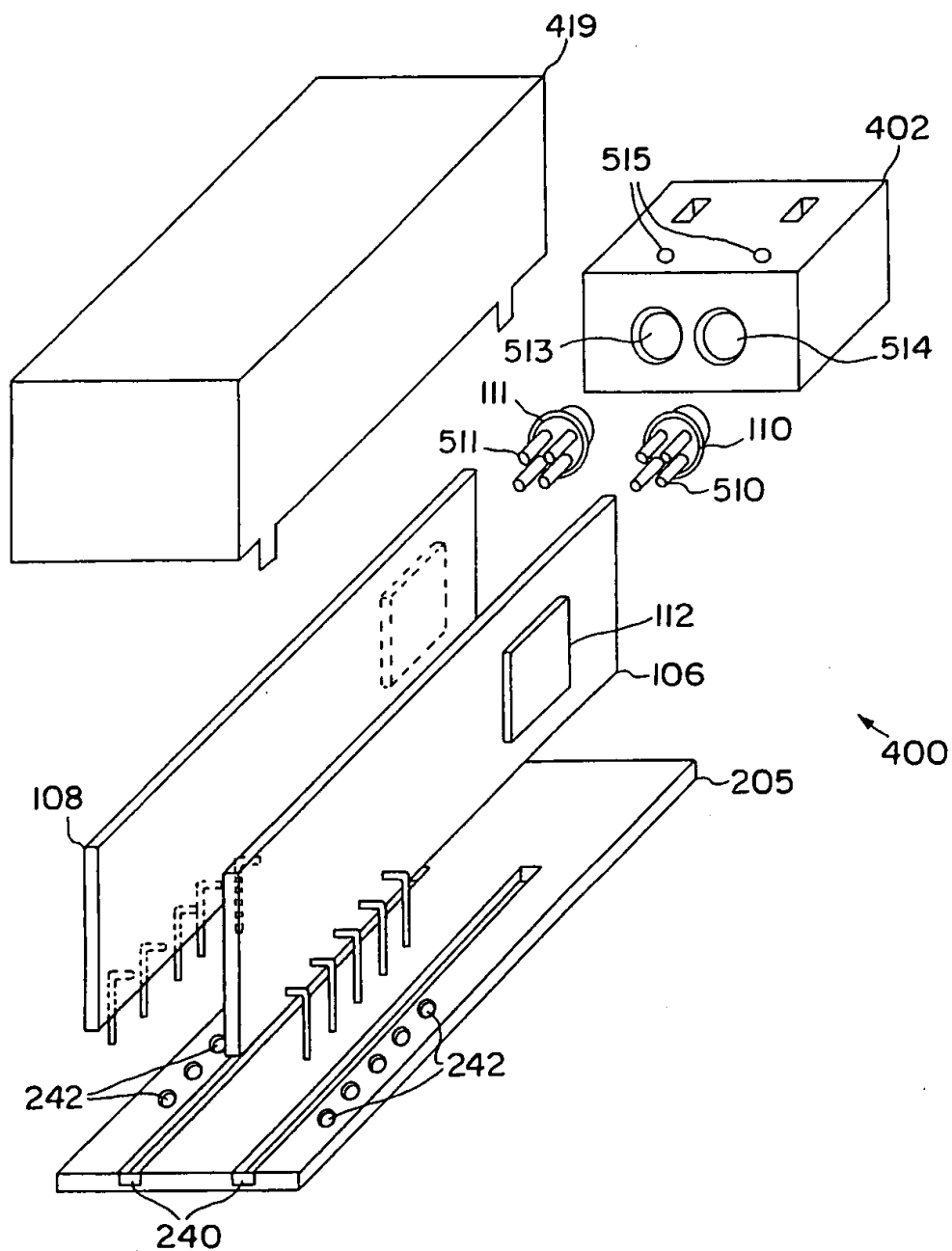
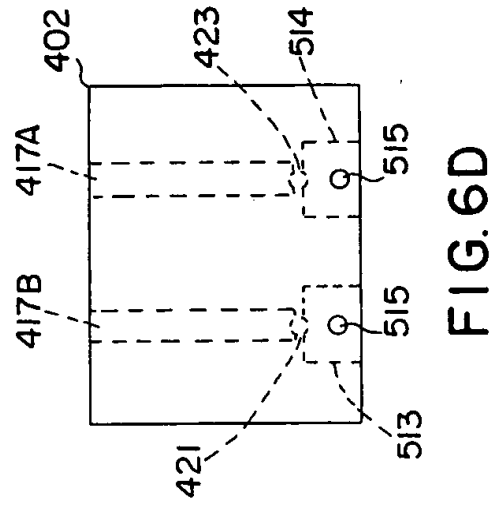
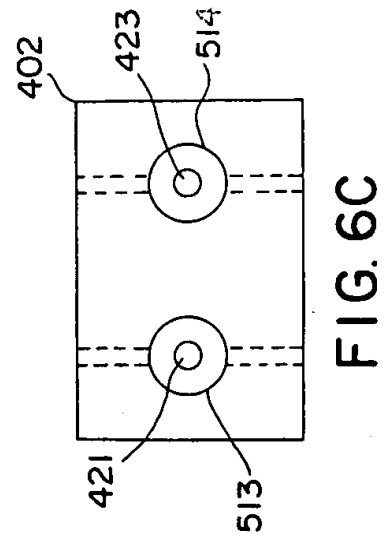
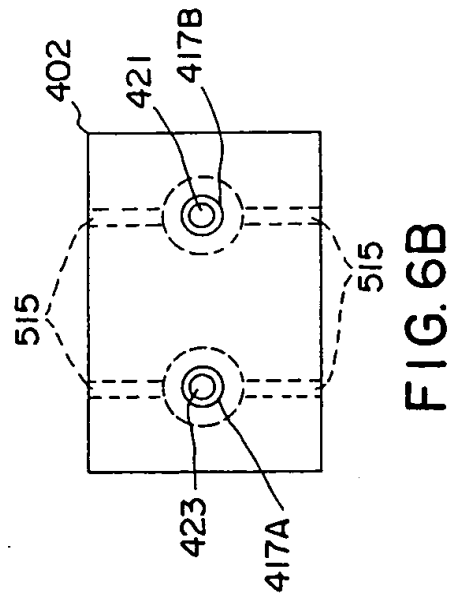


FIG. 5

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## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US00/09015

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(7) : G02B 6/42, 6/36 US CL : 385/92 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) U.S. : 385/88-94, 14  Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) BRS: ( (printed or circuit) adj3 (board\$1 or card\$1)) same (optical adj (fiber\$1 or waveguide\$1))		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,475,783 A (KURASHIMA), 12 December 1995 (12.12.1995), see entire document.	1-3, 7-11, 21-22, 24, 28-33
Y	US 5,337,396 A (CHEN et al.), 09 August 1994 (9.8.1994), see entire document.	1-3, 7-11, 21-22, 24, 28-33
X	US 3,870,396 A (RACKI et al.), 11 March 1975 (11.3.1975), see entire document.	52-54, 56-57
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